[0235] For calibration in the z-axis: The capillary was moved up from the x-position until it was clear of the laser beam. The capillary tip was moved down towards the laser beam, and stopped as soon as the laser beam was interrupted (using the same process as for the y-axis). This position was recorded as the z-position.

[0236] Capillary Priming

[0237] Before printing from a capillary, the bio-ink or support material inside the capillary was primed so that the bio-ink or support material would begin printing at the very tip of the capillary. The calibration laser was used to prime the capillary. The capillary tip was moved just above the laser beam, with the beam centered in the y-axis. The tip was between 20-100 μm above the laser beam. The dispensing piston in the printer head was driven down until the bio-ink or support material started to dispense out of the capillary tip and interrupted the laser beam. The dispensed bio-ink or support material was aspirated back into the capillary tube by driving the piston in the reverse direction (20-100 μm). The capillary was then primed and ready to dispense.

[0238] NovoGel™ Capillary Cleaning

[0239] NovoGel™ was used as a support material. In order to remove excess NovoGel™ sticking to the outside surface of the capillary tube and to avoid the excess NovoGel™ from affecting print quality, the excess NovoGel™ was removed. A wiping feature was integrated into a bulk NovoGel™ vessel. A bulk NovoGel™ vessel was fitted with a standard medical vial with an open cap for a septum to be attached. A septum was configured with a cross cut in the center of 1-2 mm thick silicone. By dipping the capillary into the bulk NovoGel™ vessel through the septum and aspirating NovoGel™, excess NovoGel™ was wiped from the capillary as it exited the vessel, and remained in the bulk vessel.

[0240] Printing of a Vascular Structure

[0241] The bioprinter and cartridge was assembled as above. The bioprinter had a stage having a Petri dish for receiving structures generated by the bioprinter. The Petri dish was coated with NovoGel™.

[0242] A two dimensional representation (see e.g., FIG. **4**) of a vascular structure was inputted by a user into a software program into a computer which was connected to the bioprinter. The two dimensional representation of the vascular structure consisted of rods of HASMC-HAEC mixed cellular cylinders, HDF cylinders, and NovoGel™ rods defining the voids of the vascular structure and surrounding the vascular structure. HASMC-HAEC mixed cellular cylinders and HDF cellular cylinders were prepared as in Example 1, and aspirated into capillary tubes for insertion into the collet chuck of the printer head. Alternatively, capillary tubes were loaded into the printer head and dipped into the bulk NovoGel™ vessel and NovoGel™ was aspirated into the capillary tube. The capillary tubes were calibrated using the vertical laser calibration system.

[0243] When the commands from the software program were provided to the bioprinter, the bioprinter would print the three-dimensional structure, alternating between HASMC-HAEC rods, HDF rods and NovoGel™ rods, onto the Petri dish, in predetermined locations. See Example 2. After each rod was laid down on the Petri dish, the rod was wetted with a small amount of culture medium. Once the entire construct was completed warm NovoGel™ was dispensed over each end of the construct and allowed to gel at room temperature, and cell culture medium was added to the Petri dish to submerge the entire construct. The construct was then incubated at 37° C. and 5% CO_2 to allow for fusion between the cellular cylinders. At the end of the incubation time, the surrounding NovoGel™ support structure was removed from the fused multi-layered vascular tube.

[0244] While the invention has been described in connection with specific embodiments thereof, it will be understood that the inventive methodology is capable of further modifications. This patent application is intended to cover any variations, uses, or adaptations of the invention following, in general, the principles of the invention and including such departures from the present disclosure as come within known or customary practice within the art to which the invention pertains and as may be applied to the essential features herein before set forth and as follows in scope of the appended claims.

1. A three-dimensional bioprinter comprising:

a. one or more printer heads, wherein a printer head comprises a means for receiving and holding at least one cartridge

b. a means for dispensing a bio-ink of a selected cartridge by application of pressure to extrude the bio-ink of the selected cartridge through the deposition orifice;

c. a means for determining a position of the selected cartridge in space; and

d. a programmable computer processor for regulating the dispensing of the bio-ink communicatively coupled to the means for determining a position of the selected cartridge and the means for dispensing the bio-ink.

2. The bioprinter of claim **1**, further comprising a means for applying a wetting agent, utilizing a sprayer or a pipette, to one or more of:

a. the receiving surface;

b. the at least one deposition orifice;

c. the bio-ink; and

d. the extruded contents of the at least one cartridge;

wherein the wetting agent is applied at one or more time points selected from: before the bio-ink is extruded by the bioprinter, substantially concurrently with extruding, and after the bio-ink is extruded by the bioprinter.

3. The bioprinter of claim **1**, wherein the means for calibrating the position of the at least one cartridge or the at least one deposition orifice calibrates along a x-axis, a y-axis, and a z-axis, utilizing the laser and the laser detector.

4. The bioprinter of claim **1**, wherein the computer processor is programmable by:

a. a graphical user interface that is capable of receiving input of a visual representation of a desired tissue construct; and

b. generating a series of commands, wherein the commands are based on the visual representation, inputted via the graphical user interface.

5. The bioprinter of claim **4**, wherein the visual representation comprises identification of one or more elements of a desired tissue construct as one or more of:

a. the bio-ink; and

b. a specific composition of the bio-ink.

6. The bioprinter of claim **1**, wherein the one or more printer heads, the at least one cartridge, or the at least one deposition orifice are moved relative to the receiving surface, utilizing the laser and the laser detector, to produce a desired tissue construct of a particular three dimensional geometry, inputted via the graphical user interface in the extruded contents of the at least one cartridge.